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Radio-Activity

A Brief Guide to
its Use in General
and other Practice

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RADIO-ACTIVITY

A BRIEF GUIDE TO ITS USE IN GENERAL & SPECIALIST PRACTICE

FOUNDED ON THE WORK OR WRITINGS OF WICKHAM, DOMINICI, DEGRAIS, RUTHERFORD, SODDY, DANLOS, FABRE, MACKENZIE DAVIDSON, MORRIS, AND OTHER AUTHORITIES IN GREAT BRITAIN AND ABROAD

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FOREWORD

The author of this booklet desires to disclaim any pretension whatever to originality. He has merely endeavoured to pick out from a very heterogeneous mass, and formulate briefly in his own language, such "authoritative" views on various points as seemed either best proved in themselves or best to fit in with their neighbours.

In such a composition there must almost necessarily be statements to which one investigator or another may feel disposed to take exception; but this is of small importance if, as the writer hopes, the whole can be regarded as a fair summary of what is at present known clinically and scientifically of a method of treatment still in the growing stage.

Taking a last glance through its pages, he seems to recognize here and there a touch of the enthusiasm of some of the optimists whose papers he has read or whose work he has seen. If so, it is not, he thinks, a matter for regret, since it may possibly inspire others to study matters for themselves. Neither radium-therapeutists, nor the general public, nor the medical profession at large, have anything to gain by familiarity with the principles and methods of radium treatment remaining the attribute of a very limited number of individuals.

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RADIO-ACTIVITY

CHAPTER I

INITIAL CONSIDERATIONS

The terms "radium," "radio-activity," and "radium-therapy" have of late years become very familiar to all readers of scientific publications, but true familiarity with what they connote is comparatively uncommon. Even among medical men the number of individuals who have thought it worth while to make themselves practically acquainted with these separate but closely allied subjects is still small—much smaller than it would have been but for the action of certain adverse factors.

These are (1) the knowledge that commercially radium is a substance of unrivalled costliness; (2) that scientifically its immense powers for good or evil are of a kind totally unconceived by the most advanced thinkers a few years ago; and (3) that the therapeutic value forthwith attributed to it was at that time purely hypothetical and in excess of what even now can be upborne by definitely ascertained facts.

In these circumstances it is not unnatural that so many medical men should have declined to pay much attention either to radium, radio-activity, or radium-therapy.

But the time has now come when such an attitude is no longer legitimate. The premisses on which medical men based a conclusion that—with perfect fairness to their own and their patients' interests—they could dispense with the familiarity with the subjects in question, leaving them to be dealt with, if at all, by an exceedingly limited class of men, are no longer sound.

Cost.

It is still, of course, true that since radium-bearing ores are scarce, and months of highly-paid labour are necessary for the production of even tiny quantities, this substance, weight for weight, is much the most costly in the world. But it is equally true that the quantities required for medical purposes are so small that that constantly quoted fact loses much of its significance.

Facts equally important are—that no one who uses radium for therapeutic purposes need necessarily buy radium, and that, thanks to careful systematization, the expense attaching to the treatment of any given case by radium can be calculated in advance with a considerable degree of precision.

Safety.

Again, while it is true that the physical attributes of radium are so far-reaching that physicist researchers still have most of their work before them, it is no longer true that medical men who handle it are dealing with an uncontrollable, unknown force. On the contrary, it is one that has been so far tamed and broken to harness that it can be used medically with perfect safety.

Therapeutic Value.

Finally, there can no longer be any doubt as to its possession of real therapeutic qualities. Very probably the best way of applying them has not yet been discovered, but meantime there is a mass of evidence that even present methods produce invaluable results. Moreover, no careful reader of medical journals can be unaware that constant additions to this evidence are being made, not alone by experts — such as those whose names appear on the title-page of this brochure —but by men who, so far as radium-therapy is concerned, are merely novices.

In short, the pioneer work has been accomplished, and—to paraphrase Napoleon's boast—the Marshal's bâton in the field of radium-therapeutics lies ready for every medical combatant in the files of countless scientific publications, British and foreign.

But it must be admitted that, though ready, it lies well concealed, and for that very reason it seemed desirable to search out all the scattered information on the subject, with a view to its analysis and the making of a compact statement of the latest and best-supported views of those who have now devoted themselves to radium work for many years.

Thus armed, many a medical man may feel himself in a position to apply the facts in his own practice, and to begin building up his own clinical experience in radium-therapy with not less assurance than that of a newly-elected Fellow of a college of surgeons when performing his first independent operation.

Others less ambitious will, at any rate, be able to follow with intelligent comprehension the precise treatment adopted by experts in radium-therapy, to whom they may prefer to entrust their cases, and often in some degree to direct and control it.

CHAPTER II

RADIUM AND RADIFEROUS SUBSTANCES

WITH the physics and chemistry of radium, and the conclusions based upon them, the radium-therapeutist need little concern himself. Despite the labours of many of the foremost physicists of the day, they still belong in some degree to the realms of hypothesis, and it is no more necessary for the practitioner to study them for himself than for every rider of a horse to attend a veterinary school. It is still open to question whether radium as a distinct entity truly exists or whether the substance thus named is not merely a mixture of other elements, which happen to be acting for the moment—a moment which is a terrestrial æon—as a prison of Cosmic force.

However this may be, if pure radium has ever been isolated at all, the amount thereof is infinitesimal. Practically it is only known in the form of salts, the recognition of whose nature depends mainly on their power of radiation or emission of " rays." These rays are a form of force—the force which has here been called Cosmic.

Radiation.

Of what is assuredly known about emission of rays by radium, the following are the points of primary importance in the present connection. The radiation is divergent, and not homogeneous, but composite—*i.e.*, it is made up of sets of rays possessing different characteristics, the principal classes being Alpha rays, Beta rays, and Gamma rays.

None of them are visible, but they can be made visible, and they can all pass through solids, thus acting photographically on hidden objects. All show electric affinities and ionize air—that is, decompose the atoms of its component gases into electric ions.

The power to emit rays is not limited to radium, but is possessed by several other seeming elements—actinium, thorium, uranium, and polonium — all of which and their salts and the substances containing them are entitled to the term "radiferous," which is reserved for substances which not merely exhibit, but create, radio-activity.

Although it has been said that the rays emitted are of different kinds, it is to be remembered that every specimen of matured radium invariably emits all rays, and that the extent to which any one of them may be recognized in the neighbourhood of a specimen of radium depends on the distance therefrom and the character of anything which is interposed between the radium salt and the point of observation.

Separation of Rays.

The power of penetration possessed by any moving body depends partly on its size, partly on its speed, and in these respects, and possibly many others, the three main classes of rays differ materially.

Alpha rays, which form roughly about 73 per cent. of all radiation output, are composed of comparatively large particles of matter, travelling comparatively slowly; they are, therefore, easily deflected, and possess low power of penetration. Beta rays, forming roughly 25 per cent. of the output, are made of smaller particles, travelling at a greater speed; hence they pass through denser substances than do Alpha rays, and any given quantity of them loses much less of its bulk in the process. But in these respects they differ also amongst themselves, and are hence subclassified as "soft," "medium," and "hard." Gamma rays, on the other hand, forming only about 2 per cent. of the output, are not particulate at all, but merely waves of ether set in motion apparently by the force developed by the sudden emission of Alpha and Beta rays. They travel so fast that they can pass through about 4 inches of even so dense a substance as lead without material reduction. Gamma rays are also capable of some subdivision, the slower-travelling rays belonging to this class being apparently identical with those arising from a Roentgen tube. It is a point of interest, but not of concern, to the radium-therapeutist.

The real point of interest is that, thanks to the very varying powers of penetration possessed by different classes of rays, it is possible to break up any given quantity of radiation into its component parts. This, on the whole, is the most important point to remember about radium. On it, as will presently be seen, depends, if not all the therapeutic value of radium, at all events the safety and precision with which its powers can be used for medical purposes.

Measurement.

The characteristics which have been indicated allow the quantity, mass, travelling speed, and precise type of rays to be determined with great accuracy in several alternative ways—the spectroscope, electroscope, and photographic plate. But with such measurements or determinations—matters of extreme nicety—the ordinary medical user of radium need not concern himself. If he is using hired radium, he is informed of the precise activity of the salt of the radium loaned to him; while if he owns his own radium, he can test its powers whenever he pleases by means of a simple rule-of-thumb appliance made for the purpose. This appliance, indeed, is a useful possession for any habitual user of radium. The strength of the rays emitted is approximately determined by the rate at which an electrically-charged filament of metal loses its charge and falls in the presence of a radiferous body.

Emanation.

Before leaving the physics of radium, one further point requires mention. It relates to a phenomenon at present wrapped in a good deal of obscurity. Possibly radium emits radiation directly, but more probably there is an intermediate step, radiation being, not the daughter, but the granddaughter of radium. In any case, radium emits a something which has been entitled "Emanation." It can be collected, and exhibits many of the qualities of a gas. More important still, it is radiferous, and renders everything exposed to its influence radio-active. It is, in short, probably the true mother of radiation, which in its turn evolves more or less rapidly into some other form of force.

For practical purposes it is convenient and also legitimate to regard both emanation and radio-activity as different degrees of ray storage, and then to suppose that the time for which such storage may persist depends partly on the constitution of the substance in which the storage is taking place, partly on the nature of that by which the substance is surrounded. If both are of such kind as to allow rays to pass freely, radio-activity may cease so instantaneously as practically never to exist at all. In the converse case, radio-activity probably remains until the stored rays die, owing to the change already indicated.

It is possibly to traces of bygone emanation that many waters and some natural earths therapeutically esteemed owe such value as they possess, while a theory of temporary ray storage also seems to offer the best explanation of the varying physiological effects of radium appliances.

Maturation.

It is also emanation which probably lies at the bottom of another curious phenomenon. In the neighbourhood of a freshly-prepared salt of radium, Alpha—but from a practical point of view no other—rays can be recognized until such salt has been protected from free access of air by a cover of some kind for a very considerable time. It then emits, and continues to emit for an indefinite period, all classes of rays, and is said to be "matured." No doubt the devolution from radium to emanation and from emanation to radiation is constant and instantaneous, but unless the emanation is, so to speak, imprisoned, the birth of radiation may apparently pass practically unobserved.

CHAPTER III

RADIO-ACTIVITY

THE power of emitting rays is known as radio-activity, and if there are a good many sources and degrees of radio-activity, there are at least as many fashions of turning it to therapeutic use. The principal appliances at present used are as follows:

1. Radium salts, loose in glass or metal containers, provided solely for their safe keeping and ready handling.
2. Radium salts, spread evenly, and fixed by a special varnish to the surface of thin plates of metal or flexible fabric of various shapes and sizes, suitable for use in various circumstances and situations.
3. Radium salts, enclosed loose in metal cases, designed less for their protection than as a means of modifying their action.
4. Natural earths, found in certain parts of the world, possessing slight radio-activity, acquired as the result of emanation from some contiguous substance in a bygone age.
5. Earths resulting from the manipulation of uranium ores, and not only markedly radio-active, but also radiferous, owing to the existence therein of minute quantities of uranium.
6. Water and other liquids, rendered radio-active either by being made the solvent or receptacle of emanations, or by mixing with them a radiferous earth.
7. Woollen and other tissues, rendered radio-active by exposure to emanations.

Of these seven methods, the first is no longer commonly used by experts. The utility of the rest and the reasons which should guide the selection of one or other of them in any particular case will appear later on.

Meanwhile, it is to be noted that the term "radio-activity," though a general one in itself, should never be applied vaguely to any appliance possessing it or fashion of using it. It is true that in the case of earths, waters, wools, and the like, radio-activity is always so low that knowledge of its precise amount is unessential, but in all other cases the radium-therapeutist must start with a clear knowledge of the radio-activity of the weapon he is handling. This, for the reasons already stated, he need rarely calculate for himself; but he must know the general principles on which such calculations are made, as otherwise he can neither control his own work nor understand the description given of their work by others.

The Radio-Active Scale.

The radio-active scale is, like all its congeners, of a somewhat conventional character. The unit of calculation is the electroscopically-determined activity of a centigram of pure uranium oxide, evenly disposed over a surface 1 centimetre square. Nominally, therefore, it is this quantity of uranium that should be kept in mind when a figure descriptive of the radio-activity of any radiferous salt is mentioned.

Practically, however, it is of the top, and not the bottom, figure of the conventional scale that it is best to think; this is 2,000,000, or the radio-activity of a centigram of pure radium bromide compared with the same quantity of pure uranium oxide. The reason why it is most convenient to look at matters in this way is that the activities commonly employed are not units, but thousands, and that a centigram of pure radium bromide is also the basis of calculation in determining the size of applicators and estimating the cost of buying or hiring radium. For this purpose all other radium salts are converted into terms of bromide.

Estimation.

The use of pure radium salts is chiefly confined to cases in which it is desired to utilize only the highly penetrative rays. Even in these it is not essential, for the vast majority of all radio-therapeutic work has been done so far by radium salts diluted down by the addition of barium and other compatible but radially inert elements. When the extent of such dilution is known, the radio-activity of a quantity weighing 1 centigram can be told forthwith. For example, the radio-activity of 1 centigram of a mixture of radium bromide and barium in equal proportions would be half that of radium bromide—viz., 1,000,000; in a 25 per cent. mixture it would be 500,000, and in a 5 per cent. mixture 100,000.

Similarly, when certain allowances had been made, the percentage composition of the contents of an applicator would be revealed by a statement of their weight and the radio-activity given, while the weight of the contents of an applicator could be calculated from the factors radio-activity and percentage composition.

But strictly from a therapeutic point of view neither of the latter calculations is of more than minor interest, the sole question of importance being the degree of radio-activity supplied. Whether an activity of 50,000 is supplied by pure radium bromide weighing only four-tenths of a milligram, or by a centigram of a 2½ per cent. mixture, appears to be of no therapeutic importance, provided the two cover the same extent of surface, and much the same remark may be made of the precise character of the radium salt used—bromide, sulphate, chloride, or other combination, as the case may be. Physiologically and in radiating power there would appear to be no material difference between any of them.

It will be seen presently that whatever the degree of radio-activity initially supplied, this is not necessarily all employed, and that in describing the treatment applied to any case the initial activity (or the weight per square centimetre of surface of the radium salt producing it), duration of application, and any means used to modify the quality of radiation, should all be mentioned.

CHAPTER IV

RADIO-THERAPEUTIC PRINCIPLES

Inasmuch as the physiology of the action of rays on living tissues is not yet fully understood, it may be said that the art of radium-therapy is still empirical—as, indeed, in some degree must all arts ever be.

Physiology.

Since the mere passage of even an impalpable body must have some effect on the structures penetrated, possibly some of the effects of radiation are due to this cause; but a theory founded on the ray storage and transformation previously mentioned perhaps offers a better explanation of the results observable.

If the storing object is a mass of living cells, and the accumulation of entangled rays takes place either very slowly or endures but a short time, the effect may be merely healthy stimulation of their normal function. If, on the other hand, it is rapid or long, total destruction of the cells involved may result. The entanglement or storage must certainly be considerable, since, after traversing skin only 2 millimetres thick, any given volume of rays is reduced to about 15 per cent. of its original bulk, and to about only 4 per cent. after traversing tissues 9 millimetres thick. After this depth the loss of bulk would appear to be very slight.

For the alternative sequences indicated there are plenty of analogies in other medico-physiological connections, and, remembering that rays are a form of force, the conception is readily credible. In addition, clinical observations tend to support its accuracy, and also afford ground for believing that the border-line between the stimulative and destructive actions is more rapidly reached in the case of pathological than of normal cells. Further allusions to this topic will be made later on.

Histology.

The changes produced by radiation, as evidenced by microscopic examination, vary considerably according to its duration and the depth from the surface, but seem to be all of the same general character. They can only be studied satisfactorily on practically normal skin. This is hardly influenced at all by highly penetrative rays unless the application is very long, in which case the effect seems to be the same as that resulting from comparatively short action of radiation as a whole.

Summed up, the initial effect seems to be due to stimulation, the nuclei of cells showing some enlargement and alteration of shape, the stroma somewhat swelling. The more superficial cells, if the process proceeds any farther, may die, the epidermis meantime peeling off. The cells lining sebaceous and sweat glands and hair follicles undergo granular degeneration and die too; they are not replaced, as are the epidermic cells.

In the deeper-lying layers normal cells are first replaced by others of embryonic type, and then these evolve into ordinary connective-tissue cells. Finally, at the end of some months, the general structure is that of fibro-elastic tissue (Barcat and Dominici).

In respect of new growths, the changes brought about would appear in their essence to be of the same general order, with the important difference that the neoplasic cells, instead of being stimulated, have their vitality lessened; their evolution ceases, and clumps of cells undergo necrobiosis. Meanwhile, whatever normal structures remain in and around the growth show increased vitality, and presumably undergo something of the same kind of double change as that described in the dermal cells. So far as the neoplasic cells are concerned, it may be that radiation has a definitely elective or specific action, but more probably their decrease is due to alterations in the blood-supply.

In any case, if the treatment has been successful the site of the original growth becomes occupied either by layers of fibrous tissue, or, in the case of a more or less circumscribed tumour, by a body resembling an innocent fibroma.

Dosage.

In any case, it is certain that it lies in the radium-therapeutist's hands to obtain a stimulative or destructive action, as he pleases. These two actions may on clinical grounds be respectively distinguished as regressive or reconstructive and destructive, and the skill of the practitioner chiefly lies in knowing when to choose the one, when the other, and when to aim at a mixture of the two, and in all cases in judging how best to achieve the result desired.

Length of Application.

It should be clear from what has already been stated that there are several ways by which the action of a radiferous substance can be modified at will. Thus, for instance, a weak salt can be used for a long time or a strong salt for a short time, and in either case the number of applications and the length of the intervals between them can be varied at will.

Filtration.

What is equally important is that the quality of the rays can also be varied at discretion. The largeparticled Alpha rays, which are esteemed the most destructive, and which predominate in all outputs of rays, can be allowed to act or can be cut off by taking advantage of the fact that their power of penetration is comparatively low. They can, in short, be filtered out. So, too, can the Beta rays, leaving the Gamma rays alone to act. In such case, of course, the radiation which comes into action is but a small fraction of the initial output. The same consideration applies relatively to all cases in which filtration is used.

Cross-Fire.

A further way of modifying action is the cross-fire method of Wickham—that is to say, the simultaneous application of radio-activity to opposite segments of a growth under treatment. It thus has the cells in its interior brought under radio-active influence from more than one direction. In addition, applicators can be brought into contiguity with deep-seated tissues by making an opening into the interior of tumours and inserting them therein.

Further details on most of these points will be found in the following chapters, as also some account of the conditions in which radium-therapy is most likely to prove effective so far as present knowledge goes.

The use of earths, baths, and slightly radio-active tissues, such as wools, falls into a somewhat different category, and will be found dealt with in the concluding chapter of this pamphlet.

Hypothetical Dangers.

There is one often overlooked principle which applies to all therapeutic measures equally. This is that if the treatment is not certain to do good, it should at least do no harm. In this respect radium-therapy is singularly free from justifiable reproach.

It is a mistake to suppose that radium is such an active substance that even momentary contact therewith might produce an unpleasant burn. On the contrary, contact for a very appreciable time would be necessary to produce any result whatever.

If this is true of naked radium, it is still more true of appliances containing radium and intended for medical use; these are much more likely to be applied for too short than too long a time. In every form of applicator some part of the total output of the contained salts is deprived of all action. The rays thus rendered *hors de combat* are fewest in the applicators consisting of fabric to which radium salt has been affixed by varnish; but such varnish, thin as it is, suffices to stop almost all the irritating Alpha rays. In the rigid fixed salt applicators the varnish is considerably thicker, and suffices to cut off approximately all the Alpha rays and some of the soft Beta rays; while the applicators with loose salts exclude all but the very hardest Beta and even a fraction of the Gamma rays. Hence contact, not momentary, but even prolonged for several minutes, would produce no effect, visible or invisible, if a loose salt applicator were in question, while even in the case of a fixed salt applicator no irritation, much less a burn, would result in the same circumstances.

CHAPTER V

TECHNICAL POINTS

At the risk of some repetition, certain points must now be emphasized.

Choice of Applicators.

Applicators are of various shapes—cylindrical, round, concave, square, oblong—and in choosing one the adaptability of its shape, and more particularly that of its active surface, to the locality which is to be treated should be borne in mind. Should it not fit, there is loss of power by diffusion of rays and air-filtration. The ratio of the radio-activity afforded by such surface to the total which can be emitted by the amount of radium contained is also of moment.

In both these respects the flexible-varnish applicators offer advantages, and are therefore possibly to be preferred if the operator is simply acquiring a radiation applicator for general use, and not for a single specific purpose. On the other hand, they are somewhat fragile, and are best suited, perhaps, for use when large surfaces have to be treated, and a comparatively low activity is thought sufficient.

As for metal-varnish applicators, they are not fragile, and are very easy to handle; but the ratio of actual to theoretic activity is comparatively low, owing to the thickness of the varnish. It is lowest of all in the cylindrical applicators containing loose salts, but here is of less importance, since the reduction is intentional. When a large surface has to be treated, it can either be divided into zones and dealt with in succession, or a number of flat or cylindrical applicators placed side by side. The cylindrical applicators are especially useful in dealing with lesions situated in crannies, and those with a very irregular surface. Other methods of dealing with extensive surfaces have already been mentioned under the heading of "Cross-Fire."

As a general rule, and in view of filtration possibilities, it is best to choose applicators whose initial activity is great. This term "great" is commonly applied to activities between 2,000,000 and 500,000 uranium units, "medium" to those of about 100,000, and "weak" to those of 5,000 downwards; but these are very vague phrases. Indeed, all present methods of describing activities are unsatisfactory; it might possibly be an improvement if activities were indicated by simply stating the area of the applicator surface used and the amount of radium in terms of pure bromide distributed over it.

Modification of Output.

Of the three factors in producing results—initial activity, duration of application, and the quality of the rays allowed to act—the first is unalterable if the operator has only one appliance. The other two rest entirely in his own hands. Moreover, he can so modify them as to get in many circumstances the same effect from an apparatus of low power as out of one many times its strength. This is because the effect of the radio-activity is cumulative. Hence an applicator of very low activity used for a long period may have much greater effect than one of high activity used only for a short time. Nevertheless, length of application will probably not entirely outweigh lack of strength when deep penetration is in view.

The Time Factor.

Given equality of initial output, the time factor is mainly determined by the effect derived and the quality and proportion of rays to be used. When a flexible varnish apparatus is applied naked, the rays are numerous, and include some of the highly irritating Alpha rays. Hence the application need be comparatively short. When a rigid varnish applicator is used, or a screen interposed, the rays are less numerous, most of the action takes place deeper below the surface, and the duration of application may be longer. With a thick filter or a loose salt applicator the number of rays is greatly reduced, the action takes place at a great depth, and the duration of applications to be effective must be greatly prolonged.

The Quality Factor.

To vary the quality of the radio-activity used, filters or screens must be employed; they, of course, greatly reduce quantity as well as alter quality. Various materials are available, but the most generally useful are fine flat or curved sheets of aluminium or lead. They can be obtained in any desired thickness, and are usually made very fine, so as to leave the operator to choose his own degree of thickness by superimposing one on another, as he may think desirable, in any given case.

Thickness for thickness, lead, being the denser metal, has the greater "stopping" power. Nevertheless, a sheet of aluminium as thin as four-tenths of a millimetre—*i.e.*, less than one-hundredth of an inch thick—suffices to stop all the Alpha and most soft Beta rays, leaving free to act the medium and hard Beta rays and the Gamma rays. Similarly, lead ranging from about five-tenths of a millimetre thick cuts off all Alpha rays, all but a few of the very hardest Beta rays, and even a fraction of the Gamma rays (Beaudoin). The radiation then becomes "ultra-penetrative" (Dominici) as distinct from "composite," the term used when all, or nearly all, the available radiation is allowed to act.

After the thickness stated, the effect of adding further screens is very slight, but up to this point the gradations in quality possibly vary precisely with the fineness of the filters used. It may here be noted that when ultra-penetrative radiation is in use, and it is desired to increase the quantity without altering the quality, two or more flexible applicators may be applied, one above the other.

Cleanliness.

By way of avoiding unintentional filtration, if for no other purpose, the skin of the part about to be treated should always be cleansed carefully beforehand, and if its surface be broken or inflamed, all crusts should be removed, and traces of ointments or other applications wiped off. Applicators may be sterilized by all ordinary means other than alcohol and heat. Also, with a view to cleanliness, it is usual to cover the applicator and any filters in use with a thin piece of india-rubber.

Accuracy of Aim.

When the applicator in use is larger than the lesion under treatment, the whole surface should be covered with lead-foil, and in this a window cut the size and shape of the lesion ; the radiation will then act where it is intended to, and nowhere else. Metal screens give off irritating secondary rays (Sagnac), the action of which should be eliminated by placing under the screens a further screen of some sheets of paper 1 or 2 millimetres thick.

CHAPTER VI

RADIUM REACTIONS

The application of radium is absolutely painless—indeed, analgesic—and the results are especially excellent from a cosmetic point of view, whether the treatment leading up to them has been "destructive" or "reconstructive." In the former case there is left not an ugly irregular pigmented scar, but a soft, supple surface, only differing from natural skin in some lack of colour, hair, and glands. In the latter case the character of the epidermis is not altered at all.

These two phrases, "destructive" and "reconstructive"—constantly to be encountered in British and foreign forms in literature dealing with radium-therapy—are useful to distinguish treatments accompanied by a breach of surface from those in which all the action is subcutaneous; but otherwise they are somewhat confusing. In all treatments the reaction obtained partakes of both characters—that is to say, there is both reconstruction and destruction, though not necessarily any breach of surface. In this connection what has been said under the heading of "Histology" should be borne in mind.

Destructive Reaction.

For about eight or ten days after intentionally "destructive" treatment no effect whatever is visible beyond, possibly, a little redness; a species of vesication then commences, resulting by the end of about three weeks in a scab covering a very superficial ulcer. In the course of a fortnight or so this scab or crust drops off, and the surface below is found to have already re-formed if the application has been only just sufficient to produce purely surface destruction of tissue. If otherwise, the crust may re-form several times, and can be removed, and the ulcer dressed and redressed so long as it continues; eventually natural tissue may be expected to take its place.

Reconstructive Reaction.

When, on the other hand, reconstructive or regressive treatment has been successfully employed, there can hardly be said to be any visible reaction at all; the result, when surface lesions are in question, is only evidenced by their gradual conversion into natural tissue, and in the case of subcutaneous growths, first by the lessening of any engorgement which may have surrounded them, and of pain, and then by their gradual shrinkage from the periphery towards the centre.

The Border-Line.

Destructive and reconstructive actions shade insensibly into one another, and there is no border-line which can be indicated as a guide in aiming at one or the other. The result depends, not only on all the factors already discussed in previous chapters dealing with principles and technique, but on the nature of the tissues themselves. These vary in their susceptibility to irritation, and hence in the readiness with which they exhibit destructive action.

Among normal structures the epidermis of the perineum and the uterine mucous membrane, for instance, seem more easily destroyed than similar tissues elsewhere; and among abnormal structures many keloids prove as little prone to destructive changes as they are susceptible to reconstructive action (Wickham, Degrais).

Laboratory Evidence.

Some general guidance in the matter is, however, offered by experiments with animals. An applicator with an initial activity of 500,000 applied naked to a guinea-pig's ear for ten minutes a day for five consecutive days causes a very superficial ulcer, which disappears in four or six weeks. Multiply the time of such application by ten or twelve, and the resulting ulcer will heal with much difficulty (Barcat and Dominici).

But the result is very different if, with the same applicator, a screen of lead half a millimetre thick is employed, supplemented, as usual, in ultra-penetrative "radiation" by a layer of paper and a sheet of thin rubber. An application of fifty minutes then produces no effect whatever; prolong it for fourteen hours, and there is still no destructive effect, only the commencement of reconstructive action. Prolong it for two or three days, and the same reaction will occur as after fifty minutes' exposure to a naked applicator, with the addition of marked deep-seated reconstructive action.

Individual Cases.

Owing to the variation in the initial activity of different applicators, in the thickness of screens, and in the lesions susceptible to radium treatment in respect both of the nature of the tissue involved, its extent, density, and the depth at which it lies, it is impossible to lay down hard-and-fast rules for the treatment of individual cases.

Of all differences that of depth is the most important, and this varies materially in all lesions, however small they may be in other respects. The operator, having judged this for himself, may then assess density and all other factors presented by the lesion, and finally decide on the form and length of radiation to be adopted.

Experience.

His judgment on all points will improve with experience, but even from the beginning he should be able to settle matters fairly satisfactorily if he has thoroughly absorbed the principles and technique described, and remembers the fine gradations of effect afforded by screens of various thicknesses, and that the deeper the lesion lies the more penetrative must the radiation be. Another point never to be overlooked is that the thicker the screens the smaller the bulk of radiation, but the greater the proportion of hard or penetrative rays. When working at a considerable depth and application is to be correspondingly long, between 2 and 3 millimetres of lead is a good thickness for a screen in an average case.

He may possibly feel greater confidence if he remembers that, though there is probably an optimum treatment for every form of lesion, it has yet to be laid down, and that meantime different expert operators obtain excellent results in dealing with lesions of identical character by very different treatments. However, an indication drawn from Wickham of those which might be adopted in a few stated conditions may possibly be useful.

Assuming that the operator is using a metal-varnish applicator of 500,000 initial activity, he might apply it for reconstructive treatment as follows:

If dealing with an entirely superficial lesion, such as a patch of eczema, he might apply it naked, leaving it on for from one to three minutes three days running, renewing the treatment three or four times, if necessary, at intervals of a week.

If the lesion were somewhat denser, he might insert between the applicator and the skin an aluminium filter from four to eight hundredths of a millimetre thick, and five or six sheets of thin paper, as well as a thin sheet of rubber. Thus protected, he might apply the apparatus five days running for from three to six minutes at a time, and renew the application after a week's interval until satisfied with the result.

When dealing with an epithelioma or a keloid requiring treatment at some depth from the surface, he might use a screen of lead one-tenth of a millimetre thick, covered with nine or ten sheets of thin paper, plus the usual sheet of thin indiarubber, and thus prepared, keep the whole applied for a quarter of an hour a day for eight days in succession, then wait a week and repeat the process if necessary.

With a growth of still greater depth he might use a lead screen half a millimetre thick for an hour a day three days in succession, repeating a week later, or a screen 2 millimetres thick for ten hours every other day for a fortnight.

In treating destructively with the same applicator some such lesion as a pigmentary nævus, he might apply it naked for three consecutive hours, or for an hour on four consecutive days; while with a deep-seated growth reaching the surface, he might use a lead screen a millimetre thick, and keep up the application for seventy-two hours straight off.

These examples merely represent legitimate treatment, not that which would necessarily be followed. Indeed, with most of the lesions indicated many operators would prefer higher initial activities, thicker screenage, and longer applications, and would always avoid scarring action. In the scars of nævi destructively treated disfiguring coloration sometimes develops after a year or two. In short, there is no routine treatment for any class of case, though possibly, if operators reported their technique not less carefully than their results (hitherto not the case), this might one day develop.

CHAPTER VII

SUITABLE CASES

WITH regard to cases which may properly be undertaken, opinions differ just as in connection with every kind of special treatment. Originally it was thought that only the most superficial growths could possibly be treated with advantage, but as time goes on and the possibilities offered by high activities and ultra-penetration are realized, it is becoming evident that even quite deep-seated structures may—if inoperable—rightly be taken in hand with some hope of success, and with definite expectation of doing good in the way of retarding progress and minimizing suffering.

The general cleaning up by the lessening of discharge and diminution of the tendency to hæmorrhàges is also an advantage in cases found to be ulcerated and far too advanced to justify the slightest hope of cure. It would seem, too, that, thanks to what may be called the de-congestive action of ultra-penetrative rays, many cases apparently inoperable may become operable.

The most firmly established results naturally concern skin lesions. All classes of these, including nævi, keloids, papillomata, vicious cicatrices, obstinate tuberculous glands, moles, birth-marks, and many forms of lupus, usually prove very susceptible to treatment, which is especially successful when points such as simplicity, absence of pain, and the after-appearance of the skin are included in the count.

Apart, too, from definite lesions, acquired or congenital, many chronic skin inflammations benefit very greatly, including X-ray dermatitis (Mackenzie Davidson) and pruritus (Deane Butcher). The same may apparently be said, too, of certain superficial inflammatory disorders of the front of the eye, especially "spring catarrh" (Mackenzie Davidson).

As for malignant and semi-malignant conditions, the results seem to vary on the whole somewhat less in accordance with their nature than with the depth of the tissue involved. Angiomata and lymphadenomata yield easily, while of plainly malignant growths those of a sarcomatous nature yield, other things being equal, more easily than the lesions rightly classed as cancerous. The difficulties attaching to surgical treatment of lymphadenomata of mucous membranes and those of the parotid glands are not to be forgotten in this connection.

Ordinary epitheliomata may be attacked with considerable confidence, with the exception of those which involve a mucous as well as a skin surface. There is always a certain difficulty in dealing with mucous surfaces, owing to their susceptibility to irritation, and it is very obvious in connection with cancerous lesions. However, ultra-penetration presents proved possibilities even here (Dominici), but when in mouth lesions muscles have been reached, favourable results are very improbable. Cases of leucoplakia and rodent ulcer are also suitable for treatment; the latter, if fairly circumscribed, seem to yield as easily as other forms of skin diseases, while if extended and deep, their recesses can be favourably influenced by cylindrical ultra-penetration applicators better than by any other means open.

Various gynæcological conditions are not considered out of reach (Tuffier), and benefit, in the way of retardation of progress and arrest of pain, would seem to result sometimes in cases of malignant disease of the abdominal viscera.

All these remarks, however, should be read in conjunction with the statement that the more level-headed radium-therapeutists are not disposed to dispense with the assistance of the surgeon in the treatment of malignant or subcutaneous growths when these are susceptible to knife treatment; and that they even rely upon their assistance when the growths are comparatively superficial, but of such extent that a rapid cure is more likely to result if the knife or curette (Langlet Sordeau) removes a good deal of it to start with. *Per contra*, they hold that when malignant growths are awaiting radical treatment by the knife, the interval may wisely be used for an ultra-penetrative application, and that radium-therapy should always be employed post-operatively in the same fashion as X-rays, but in preference to them in view of the higher penetration secured.

The knife is also employed with increasing frequency for the insertion of ultra-penetrative cylinders (Dieffenbach, Abbé, Dominici) into the interior of such voluminous growths as primarily, at any rate, are deemed inoperable: in these cases such cylinders are best made of silver. Aseptic principles must, of course, be observed.

CHAPTER VIII

RADIO-ACTIVE EARTHS

The methods of applying radio-activity which remain to be considered enter into a completely different category from the foregoing. They include (1) radio-active materials, such as wools, intended to be applied to the body, either as garments or in some other fashion; (2) water and other liquids rendered radio-active by emanation; and (3) radio-active earths or muds. The two former need only be mentioned in passing, since their use has not yet been put on a scientific basis, and, so far as class 2 is concerned, they are, for sundry reasons, unlikely to be used outside hydropathic establishments. Moreover, much of such ground as they might possibly cover is now annexed by one of the radio-active earths to be described.

Natural Earths.

It will be remembered that some Continental spas have obtained a reputation for the treatment of rheumatic and other conditions by mud-baths, and recent investigations show that the benefits received are probably due to such mud being radio-active. That it does possess radio-activity is certain, but the amount is minimal, and it disappears if attempts are made to use such muds elsewhere than close to the locality in which they are found. Such earths or muds, therefore, have little practical interest except for medical men practising at these spas and to the patients who visit them.

Uranium Mud.

Fortunately, however, there is another radio-active earth or mud which is not only available for use by medical men anywhere and everywhere, but is possessed of permanent radio-activity of much higher strength than that of the muds previously mentioned.

This is a by-product formed during the process of breaking up uranium ores in the search for radium; it is reddish-brown in appearance, and of the consistency of soft paste. When desiccated, it is found to consist of the oxides of iron, uranium, and manganese, the sulphate of sodium, and the carbonates of sodium and calcium, together with radio-active substances. Thanks to the latter circumstance, this earth is not merely a radio-active, but also a radiferous, body of almost constant strength—viz., 0·15 per centigram. That strength is some fifty times higher than the highest known strength of natural radio-active mud, and, besides this, is permanent. The radio-activity is due to traces of radium, polonium, and actinium, but the part played by the two former is practically negligible, and the whole activity should be ascribed to actinium.

Actinium.

Actinium, it may be noted, is a body of some ten times higher activity than radium, but to what extent, if any, its radiation differs from that of radium has not yet been finally established. On this point it need merely be said that all the three main classes of rays—Alpha, Beta, and Gamma rays, which have already been mentioned—are present in the radiation, but in homogeneous form. That is to say, none of the classes seem separable into sub-classes.

For all practical purposes, however, the radiation of the two bodies may be regarded at present as identical, if the question of output in the case of uranium muds is not overlooked. Such output—viz., 0·15 per centigram—is very small as compared with that of the radium salts hitherto discussed, but it is quite sufficient to be physiologically effective.

Mud Phenomena.

Study of this effect has hitherto not been general, but it has gone on sufficiently long at the Salpêtrière Hospital at Paris and elsewhere to enable it to be stated definitely that there appears to be a wide field for the beneficial use of this uranium mud in the daily work of general practitioners.

The technique required is of the simplest kind, filtration is unnecessary, and there is no occasion to consider the multiple points demanding thought before treatment by radium salts is commenced. No pain is caused, nor has any really harmful effect been noted, even if the whole body, instead of a small patch thereof, has been exposed to the radio-activity emitted by this mud for periods of hours. At the most, the combination of radio-activity with moisture gives rise to slight erythema, but this passes away quickly, and can be avoided altogether by slightly abbreviating treatment, or lengthening the intervals between applications when the skin shows abnormal irritability.

The physiological effect, in short, appears to be always what has been called in the earlier part of this pamphlet stimulant or reconstructive, and never destructive.

Indications for Use.

In view of the foregoing circumstances, and the fact that the cost of uranium mud is actually small and relatively microscopic as compared with that of radium salts, uranium mud lends itself to use in quite different conditions to those discussed in earlier chapters. Large joints can be brought under the influence of radio-activity, and the whole body, indeed, brought under the influence of that force.

Technique.

It may be employed either as a local application or for the preparation of baths. In the former case the part to be treated is covered with a layer of mud about half a centimetre thick, this layer being covered by a piece of oilsilk fixed by a bandage. This layer of oilsilk is necessary in order to keep up the output of radiation, which ceases when the earth is dry. Moreover, the dry earth sometimes gives rise to a feeling of irritation or itching. If the application is to remain in place for a very long time, it is well to interpose between the oilsilk and the mud a moist compress. Over such compress a layer of dry wool can be placed instead of oilskin, if the skin proves easily irritated.

The preparation of a bath is equally simple, all that is necessary being to mix the mud in warm water at blood heat in the proportion of about 250 grams to every 200 litres, or in British measures about 8 ounces to 40 gallons. It is not desirable to use less than the amount stated, but no harm results from using a higher proportion. As much as 1 kilogram of earth in a bath of 200 litres has been used without harmful result.

Rheumatic Arthritis.

Cases in which either large or small joints have become painful and deformed by rheumatism and gout, and the alleged combinations of the two diseases, such as are described in various terms, seem to benefit materially from the use of uranium mud, applied either locally in the form of the compresses, or dissolved in a bath when there are too many joints affected to be conveniently treated by mud alone.

The effect to be expected is the removal of pain, diminution of enlargement, and greatly increased mobility (Claude). The joints of the upper limbs commonly prove more open to improvement than those of the leg. If local applications are used, it is best to begin by applying the mud compresses for a period of three or four hours, repeating them, if necessary, for two or three days in succession. Excellent results may, it seems, be effected quite rapidly, but sometimes ten or fifteen applications are required. If need be, the local applications can be left in place throughout the whole night, provided that arrangements are made for keeping them damp.

Gonococcal Rheumatism.

Cases of subacute gonococcal arthritis may be treated on the same lines with expectation of benefit resulting. There are certain reasons for believing that the radio-activity emitted is not bactericidal, and that the benefit noticed is due to the increased resistance set up in the tissues themselves, thus leading to lessening and reabsorption of the serous fluid exuded.

Affections of the Nerves.

Uranium mud, whether used locally or for the preparation of baths, appears to have a distinctly analgesic effect, and has been used with good results in a large number of cases of neuralgic pain, and in the treatment of neurasthenics. There is reason to believe that local applications might be used with advantage in cases of paralysis accompanied by painful spasms.

Skin Diseases.

Conditions accompanied by pruritus often yield promptly to mud treatment; so, too, do some cases of psoriasis and many of dry eczema.

Gynæcology.

At the Lariboisière Hospital in Paris investigations have been carried on into the action of uranium mud on the uterus, the vagina, and the appendages. The cases so far reported were all treated on the same lines—namely, by applying uranium mud in the form of a compress to the lower part of the abdomen for several hours, and making a vaginal injection night and morning of water in which uranium mud, 20 grams to 2 litres, had been dissolved.

The patients were women exhibiting evidence of inflammatory action, either of gonococcal or other somewhat acute character, in the uterine annexes, the ovaries, or the cervix and vagina. These patients were not subjected to any other treatment than that indicated, and they were allowed to be up and occupy themselves in various fashions. Nevertheless, arrest of pain and diminution of swelling and any discharge previously noted resulted (Fabre).

From these facts it would seem that uranium muds have a future before them, and that their possible utility in any given case should not be overlooked in general practice.

Before concluding, it may be observed that when using uranium mud for the preparation of vaginal injections, or for application to raw surfaces, it may be sterilized by heat without loss of activity.

Finally, it may be noted that, as some patients suffering from rheumatic disorders are very susceptible to moisture, it is often desirable to curtail the length of an application, and repeat it after a short interval, while no bath should be prolonged for such a period as to exhaust the patient or macerate the skin. During the progress of a bath the mud should be well stirred up, and on its conclusion the patient should be washed over with plain water, dried rapidly, and made to rest for at least an hour.

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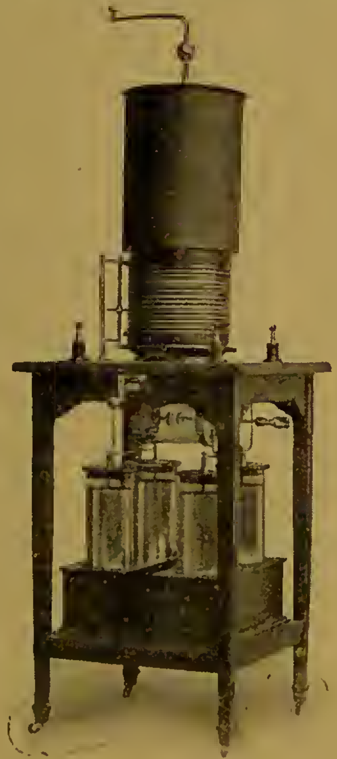

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